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By

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Thesis Summary

As one of the most prevalent childhood mental disorders, Attention-Deficit/Hyperactivity Disorder (or ADHD) is a topic that deserves ample amounts of research. Research has already repeatedly shown that social impairment frequently accompanies ADHD in both children and adults. What research has yet to discover is *why* social impairment is associated with ADHD.

Social impairment in combination with ADHD has been identified in children as young as preschool age. In people with ADHD, social impairment expresses itself in a number of ways, including difficulty being accepted by peers and difficulty developing social skills. Through research on children's story comprehension, it has been found that executive functions, such as problem solving, tend to be impaired in children with ADHD as well. Some research has even found impaired executive functioning to be a cause of the social impairment associated with children with ADHD. One type of executive function that has been studied in this capacity is pragmatic language ability. Pragmatic language is the use of language in social settings, and it is involved in problem solving skills. Based on the prior research available, this study was interested to discover if problem solving skills could play a role in the relationship between ADHD symptoms in children and their social impairment.

To discover if problem solving mediates the relationship between ADHD symptoms and social impairment in children, three hundred seventy-two children and their parent or guardian participated in this study. Problem solving skills were assessed by the children's completion of the Test of Problem Solving 3 – Elementary Version. ADHD symptoms were assessed by researchers primarily through the parent's completion of the Disruptive Behavior Disorder Scale. Social impairment was assessed by looking at the children's level of social skills, which was measured by the Social Skills Improvement System completed by the parents. The Test of

Problem Solving examined six different types of problem solving. The six different types were referred to in this study as making inferences, sequencing, comprehending negative questions, creating the best solution, predicting, and determining causes.

After statistical analyses were run on the data, it was found that only creating the best solution acted as a mediator between ADHD symptoms and social skills. Creating the best solution involves the abilities to recognize a problem, think of solutions, evaluate the options, and choose the most appropriate solution for the situation. Researchers believe creating the best solution mediated when the other problem solving types did not perhaps because it involves more steps. If creating the best solution requires more mental effort than the other problem solving types, proper completion of it will have a greater impact on social skills.

The results of this study provide partial support for the hypothesis that problem solving skills mediate the relationship between ADHD symptoms and social impairment. The results also indicate that the relationship is significantly more complex than originally hoped. This study, along with specific variations of it, needs to be repeated to ensure the reliability of the results. With more research, better treatment programs can be designed to alleviate the social impairment experienced by children with ADHD.

Abstract

This study tested the hypothesis that problem solving skills mediate the relation between ADHD symptoms and social impairment in children. Problem solving skills were evaluated by the Test of Problem Solving 3 – Elementary Version (TOPS), which separated problem solving skills into six different subtypes: making inferences, sequencing, negative questions, problem solving, predicting, and determining causes. ADHD symptoms were assessed through the parent report of the Disruptive Behavior Disorder Scale (DBD). Social impairment was assessed through the parent report of social skills using the Social Skills Improvement System (SSIS). Three hundred seventy-two (372) children between the ages of eight and ten years old and one of their parents or guardians participated in this study. The results found that the subscale problem solving mediated the relation between ADHD symptoms and social skills (ab = -.06, 95%CIs = -.00 to -.14). None of the other constructs measured showed mediation. These results provide partial support for the hypothesis. More research needs to be done to fully understand the complex interaction of problem solving skills, ADHD, and social impairment.

ADHD and Social Impairment among Children: Problem Solving Skills as a Potential Mediator

Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder that is first displayed in childhood but continues throughout adolescence and into adulthood (American Psychiatric Association, 2013). ADHD is one of the most prevalent childhood behavior problems with estimates as high as 10% of children (Barkley, 1990). As such, understanding the disorder and learning ways to overcome and cope with its symptoms is crucial. The purpose of the current study is to discover if the social impairment associated with ADHD can be mediated by problem solving skills.

Social Impairment in ADHD

Core symptoms of ADHD include problems with inattention, disinhibition, impulsivity, and executive function of working memory and planning (Douglas, 1983; Flory et al., 2006). While not currently considered a core deficit by the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), social impairment is still a well-documented correlate of ADHD (Staikova, Gomes, Tartter, McCabe, & Halperin, 2013). Some researchers even think that impairment of social functioning is so pronounced for children with ADHD that it should be considered a core deficit (Marshall, Evan, Eiraldi, Becker, & Power, 2014). Even without being seen as one of the core deficits, however, social impairment remains an important associated feature of ADHD and has been observed in 52 to 82 percent of all children with the disorder (Staikova et al., 2013).

Social problems for those with ADHD have been reported by their peers, teachers, and parents, sometimes as early as preschool age (DuPaul, McGoey, Eckert, & VanBrakle, 2001). Social impairment in children with ADHD often results in family problems and neglect or

rejection by peers (Marshall et al., 2014). These social impairments have been shown through smaller numbers of reciprocated friendships, lower ratings on social preference, and more frequent dislike by peers (even within the first twenty minutes of social exchange) as compared to nonADHD peers (Bickett & Milich, 1990; Erhardt & Hinshow, 1994; Hoza et al., 2005).

When compared to children without ADHD, children with ADHD tend to have a harder time being accepted by peers, maintaining friendships, and developing social skills (Hoza et al., 2005; Wheeler & Carlson, 1994). The specific expression of the social impairment, however, is not ubiquitous because some children with ADHD experience more disruptive and intrusive type behavior problems which lead to rejection by peers, while others display more passivity and avoidance behaviors which lead to peer neglect (Marshall et al., 2014). The rejection and/or neglect from peers exacerbate the social problems because it limits the opportunities available to practice social skills (Hoza, 2007). Peer rejection has also been associated with many long-term problems such as academic difficulties, school dropout, substance abuse, delinquency, and increased rates of psychopathology (Greene, Biederman, Faraone, Sienna, & Garcia-Jetton, 1997; Klein & Mannuzza, 1991). Social impairment does not end in childhood; it results in higher rates of divorce and job loss for adults with ADHD (Friedman et al., 2003). Out of the impairments typically associated with ADHD, social impairment is especially prevalent and lasting (McQuade & Hoza, 2008). Since childhood social impairment negatively affects later social adjustment, understanding what contributes to and maintains social impairment in children with ADHD is crucial (Parker & Asher, 1987). Through examining problem solving skills as a mediator of the link between ADHD symptoms and social impairment, the current study hopes to identify factors that could be targeted to reduce social impairment in this population.

Problem Solving Skill Deficits in ADHD

Social impairment is not the only problematic correlate of ADHD. Growing evidence indicates that children with ADHD consistently have problems with executive functioning (Nigg, 2001). Executive function is the management of cognitive processes in the brain, such as working memory, planning, and problem solving. Certain executive functions (planning and working memory) are even considered core symptom deficits of ADHD (Flory et al., 2006). In this study, we are particularly interested in learning more about the problem solving component of executive functioning. We will be looking at six different components of problem solving skills: making inferences, sequencing, comprehending negative questions, creating the best solution, predicting, and determining causes. These problem solving constructs cover all six of the cognitive levels that Bloom, an important researcher of learning in children, identified (Bowers, Huisingh, & LoGiudice, 2005). His cognitive levels are knowledge, comprehension, application, analysis, synthesis, and evaluation; the four that he identified as most advanced and important (application, analysis, synthesis, and evaluation) are emphasized in the problem solving constructs (Bowers et al., 2005). Knowledge is the most basic thinking skill level, and it involves recalling bits of information (Bowers et al., 2005). Comprehension is the skill level at which information is understood; events can be described and explained though not yet related to other material (Bowers et al., 2005). Application is the cognitive level at which previously learned information can be used in new situations (Bowers et al., 2005). Analysis involves breaking a whole into its separate parts (Bowers et al., 2005). Synthesis is the thinking level at which parts can be combined to create a new whole and relationships can be compared; it is the use of prior knowledge to form new or creative ideas (Bowers et al., 2005). Evaluation is the ability to justify answers; the cognitive level at which opinions can be clearly stated and reasons

for them provided (Bowers et al., 2005). Because these problem solving constructs cover the entire range of cognitive levels, they should provide a fair and complete test of children's problem solving abilities.

Researchers have found that children's comprehension of stories can be used to assess many facets of executive functioning. Examining how children understand stories provides insight about the strategic allocation of attention, the use of story structure, the selection, encoding and interpretation of important information, the use of retrieval of relevant background information, the generation of inferences that allow interpretation of presented information, and the monitoring of comprehension (Lorch, Milich, & Sanchez, 1998). In other words, evaluating children's story comprehension provides insight into basically every aspect of children's executive function, including problem solving, so this technique can be used to learn more about children's problem solving skills (Berthiaume, Lorch, & Milich, 2010). Researchers of story comprehension have found two main regions of impairment in how children with ADHD understand and remember stories (Berthiaume et al., 2010). The two regions of impairment are difficulty using the goal structure of a story to create an accurate and cohesive story representation and difficulty understanding how events in a story are causally related to one another (Berthiaume et al., 2010). A lack of understanding of causal relations and goal structure is likely to impair problem solving abilities.

In order for a representation of the story to be formed or causal relations of events in the story understood, coherent comprehension of the story must occur first. Knowledge of both individual events and bits of information and the relations between those events and pieces of information is necessary for clear comprehension of a story (Stein & Glenn, 1979; Trabasso & van den Broek,1985). Researcher van den Broek (1990) states that understanding the causal

relations between events may be particularly important for developing a coherent understanding of a narrative. Causal relations between events are frequently not explicitly explained, so they must be inferred. Inferring means reaching a conclusion based on information provided but not explicitly stated and is a type of problem solving (Trabasso & Magliano, 1996). There are three types of inferences: explanatory, predictive, and associative (Berthiaume et al., 2010). Explanatory inferences are believed to be the most important for story comprehension because of research performed by Trabasso and Magliano. Their research showed adults predominantly relied on explanatory inferences when articulating their understanding of a story (Berthiaume et al., 2010). Often answering "why" and "how" questions involved in explaining story characters' emotions and goals, explanatory inferences call for backward processing (Berthiaume et al., 2010). Certain types of problem solving also utilize backward processing (Bowers, Huisingh, & LoGiudice, 2005). For a person to form and effectively use explanatory inferences, he or she must link current story material with previously stated story material and link prior general knowledge to story information (Berthiaume et al., 2010). Explanatory inferences generally fill in implicit causal connections, and are therefore essential for story comprehension (Van Neste, Hayden, Lorch, & Milich, 2015). Studies have found that boys with ADHD are less able than boys of the same age without ADHD to make appropriate explanatory inferences (Van Neste et al., 2015). Making explanatory inferences is a type of problem solving (Bowers et al., 2005).

The process of forming explanatory inferences is known as inferential processing. Inferential processing is a cognitive process that has been identified by the academic research community as a skill (like problem solving) that is critical for academic success, an area in which children with ADHD typically struggle (Pearson, Dole, Duffy, & Roehler, 1992). Inferential processing is the use of information from stories or from general knowledge to determine the

meaning of ambiguous words or phrases or to connect events or ideas in the story (Berthiaume, 2010). Inferential processing is needed to connect story events and to incorporate them into a rational mental representation (van den Broek et al., 2005). In one study, children with ADHD generated fewer plausible explanatory inferences than the children without ADHD during both story processing and story recall tasks (Van Neste et al., 2015). Differences in patterns of recall between the children with and without ADHD in this study were significantly mediated by the group differences in generating inferences (Van Neste et al., 2015). In another study, boys with ADHD gave a similar number of plausible explanatory inferences as the comparison boys, but they gave significantly more implausible explanations (Berthiaume et al., 2010). The researchers surmised that the elevated rate of implausible explanatory inferences meant that boys with ADHD had trouble keeping track of all the information relevant to making connections between characters' goals and actions, so when they felt an explanation was warranted, they often drew from story information that was no longer accurate or from irrelevant general knowledge (Berthiaume et al., 2010). Difficulty recalling relevant information when necessary is a typical problem experienced by those with ADHD, and it makes effective problem solving more difficult. Studies have also suggested that children with ADHD recall a somewhat lesser amount of information from stories, yet are equally sensitive to the relative importance of story information as those without ADHD (Lorch et al., 1998). In addition, when recalling a story, children with ADHD repeat themselves more frequently and use a greater amount of ambiguous references (Flory et al., 2006). When the impairment in generating inferences is accounted for, however, there is no difference in the amount of story information recalled between the children (Van Neste et al., 2015). Clearly, impaired inference making has widespread effects on executive function performance.

Researchers wanted to know if deficits in making inferences were due to problems in the executive function of sustaining attention or selective attention. To discover which one was the cause, they created two different conditions in which a student would be asked to attend to a televised story; in one condition toys were present in the room with them, and in the other toys were absent (Lorch et al., 1998). If children with ADHD attended less than their nonADHD peers in both conditions, then the problem would lie in sustaining attention (Lorch et al., 1998). However, what instead resulted was that children with ADHD attended less than their peers only in the toys present condition, meaning that the problem for children with ADHD is in selective attention (Lorch et al., 1998). Attending to the story on the TV was measured by the number and length of looks at the screen (Lorch et al., 1998). The level of visual attention to the story by boys with ADHD when toys were present was not associated with any difference in the frequency of looks at and away from the television, meaning the overall lower levels of visual attention among boys with ADHD was due to looks that were shorter in average length (Lorch et al., 2000). Earlier research with nonADHD children and adults has indicated that, compared to short looks at the television, episodes of sustained looking are associated with greater cognitive engagement and deeper processing of a televised story (Lorch et al., 2000). The amount of time spent in deeper cognitive processing during sustained (long) looks at the TV helps explain the differences in recall between children with and without ADHD (Lorch et al., 2006). The decrease in amount of visual attention also accounted for a decrease in understanding of the causal connections between events in children with ADHD, while children without ADHD were able to maintain an understanding of the relations among events, even when their visual attention decreased (Lorch et al., 1998). Children with ADHD are not inherently deficient in the skills necessary to understand causal connections; rather, their grasp of causal connections is more

fragile than that of comparison children, so the connections can only be comprehended when the children are able to focus their attention entirely on the story (Lorch et al., 2000). Because of this relation, children with ADHD do not benefit as much from a story's causal structure when recalling story events as do children without ADHD (Lorch et al., 2000). The types of errors that children with ADHD are prone to make on different tasks all have in common difficulties in maintaining activation of all relevant information in order to make connections between story events, which results in difficulty producing a cohesive and organized account of the story (Berthiaume et al., 2010; Lorch et al., 1998). Difficulty maintaining activation of all relevant information also impairs problem solving ability.

The impaired use of goal structure to create a mental representation of a story essentially comes down to the impairment in generating explanatory inferences which children with ADHD have. Children with ADHD's impairment in understanding causal relations between events has been identified by researchers as a problem with understanding cause and effect, which results in an inability to accurately predict sequencing of events in a story. Making inferences and predicting causal effects from given information are both elements of problem solving skills (Bowers et al., 2005). Problem solving is a cognitive process controlled by executive functioning, and story comprehension is a technique researchers use to assess executive functioning deficits (Berthiaume et al., 2010). Understanding executive function deficits is important because they can lead to social and academic impairment (Flory et al., 2006). This study seeks to discover if the executive function of problem solving mediates the relation between ADHD symptoms and social impairment. The measure this study uses to evaluate problem solving skills employs some aspects of story comprehension.

Social Impairment and Pragmatic Problem Solving Skills

This study looks at the executive function of problem solving to see if it mediates the correlation between social impairment and ADHD symptoms. Executive function deficits and social impairment are both features of ADHD. In fact, research is now showing that executive function deficits may play a role in causing social impairment (Bunford et al., 2014). Studies have shown that executive functions like inhibition and working memory are necessary for proper social functioning in children with ADHD (Huang-Pollock et al., 2009; Kofler et al., 2011; Rinsky & Hinshaw, 2011). Pragmatic language abilities are an executive function that also has been shown to impact social impairment (Staikova et al., 2013). Pragmatic language ability is one piece involved in problem solving. Since pragmatic language ability impacts the extent of social impairment experienced by children with ADHD, perhaps problem solving skills as a whole will also impact social impairment.

The definition of pragmatic language is the real life (nontheoretical) use of language in social situations (Staikova et al., 2013). Pragmatic language abilities are lacking in many children with ADHD and may account to some degree for the elevated rates of social impairment in that population (Staikova et al., 2013). Since communicating requires the capacity to initiate, respond, and maintain attention, it is not shocking that several symptoms of ADHD are related to pragmatic deficits (Brue, Thernlund, & Netteldladt, 2006). Some studies have now demonstrated that children with ADHD have a wide range of pragmatic language problems that are independent of general language difficulties (Bishop, 2000; Staikova et al., 2013). In one study, pragmatic language skills, measured by parent ratings of discourse management, fully moderated the relation between ADHD and social impairment (Staikova et al., 2013). The impact of pragmatic abilities was so great that once discourse management was included, ADHD no longer

predicted social impairment with any level of significance (Staikova et al., 2013). This discovery is consistent with Vygotsky's respected theory from 1962 on the importance of language in children's thinking and in their development of self-regulation (which is another function that children with ADHD struggle to perform) (Aberson, Shure, & Goldstein, 2007). It is already known that insufficient language skills play a role in the relation between ADHD and social impairment and that sufficient language skills are necessary for successful problem solving, but perhaps that is not where the connection ends. Fixing pragmatic language skills is not a guarantee to fix all problem solving deficits, so problem solving skills may still influence social impairment beyond mere language abilities. This study seeks to discover if problem solving in the bigger picture can mediate the relation between social impairment and ADHD symptoms.

As stated, pragmatic language abilities are a portion of social problem solving skills. Studies have shown evidence that social problem solving also relies upon executive functions for the regulation and control of behavior (Barbey et al., 2012; Miller & Cohen, 2001). Other findings have indicated that executive and social functioning can predict differences between children in everyday problem solving abilities (Barbey et al., 2014). Social problem solving is the collection of mental processes and strategies involved in making decisions and solving problems that can be encountered in everyday social life (Cornelius & Caspi, 1987; Dimitrov et al., 1996). The measure used in this study to evaluate problem solving skills incorporates many social situations. Frequently, programs designed to teach social skills promote problem solving ability (Özcan, Oflaz, Türkbay, & Freeman Clevenger, 2012). One program that was developed primarily to deal with the social problems of typical (nonADHD) children utilizes an approach for prevention of high risk behaviors by providing children with assessment abilities to help them

solve their problems (Özcan et al., 2012). If problem solving skills are important for the social functioning of nonADHD children, they may be even more important for children with ADHD to learn because of the deficit the children tend to already have in categories of executive functioning. Strengthening the capacity of children with ADHD to solve problems in ways other than their typical, socially-undesirable behaviors (such as physical and verbal aggression, impulsivity, inability to wait or take turns, inability to delay gratification, and low frustration tolerance) may increase their ability to maintain friendships (Özcan et al., 2012). Although problem solving alone may not improve the ability of the brain to focus nor stop severe symptoms of ADHD, it can help reduce impulsivity by teaching children that problem solving techniques exist other than their traditional fight-or-flight response (Aberson et al., 2007). Problem solving strategies may also reduce the severity of comorbid conduct and emotional disorders and improve abilities in planning, initiating tasks, and self-monitoring (Aberson et al., 2007). Because problem solving skills can improve other areas of ADHD impairment and a piece of problem solving skills can improve social impairment specifically, this study wants to find if problem solving skills as a whole can mediate the relation between social impairment and ADHD symptoms.

Current Study

The goal in the current study is to assess whether or not pragmatic problem solving skills mediate the relationship between ADHD symptoms and social impairment. As discussed, there are many components to problem solving skills. This study will look at six components of problem solving skills that are all applicable to both story comprehension and social contexts. The six components are making inferences, sequencing, comprehending negative questions,

creating the best solution, predicting, and determining causes. The six components of pragmatic problem solving skills will be measured by the Test of Problem Solving 3: Elementary (TOPS 3). TOPS 3 refers to comprehending negative questions simply as 'negative questions' and creating the best solution as 'problem solving'. The rest of the constructs are referred to by the same name in TOPS 3 as in this paper. Social impairment will be measured by the parent version of the Social Skills Improvement System (SSIS), and ADHD status will be determined continuously by looking at symptoms, rather than a diagnosis, presented in the parent version of the Disruptive Behavior Disorder Scale (DBD) and other measures. Based on the skills and deficits involved in ADHD and executive functioning discussed above, it is hypothesized that making inferences, sequencing, predicting, and determining causes will each be able to mediate the correlation between social impairment and ADHD symptoms in children.

Methods

Participants

Three hundred seventy-two (372) children along with one of their parents or a legal guardian participated in the Social Behavior Study either at the University of South Carolina or Ohio University. Sixty-three percent (63%) of the child participants were male, and the mean age was 8.88 years old with a standard deviation of 0.81. Forty-three percent (43%) of the participants identified as African American, 43% as Caucasian, 12% as biracial, 1% as Asian, and 1% as American Indian or Alaskan. Six percent (6%) of the participants identified as Hispanic/Latino. The socioeconomic status of the participants' families ranged from less than $10,000 a year to more than $200,000 a year, with the mean and mode annual income falling between $25,000 and $49,999. The average level of education for the parents of the participants

was partial college or an Associate's Degree. After diagnostic criteria were collected and analyzed, 46% of the children were identified as having ADHD.

To be eligible to participate, all children had to be between the ages of 8 and 10 years old on the day of their initial evaluation and currently enrolled in public or private school (no home schooled children were allowed to participate). Other children that were excluded from participating were any with a previous diagnosis of autism, pervasive developmental disorder, intellectual disability, or a severe visual or hearing impairment. If a child was currently taking any psychiatric medicine other than stimulant medication for ADHD, the child was also not eligible to participate. On the day of evaluation, participants were asked not to take their stimulant medication if applicable. If the child had taken stimulant medication on the day of his or her evaluation, the evaluation was rescheduled. Once a child came in for evaluation, if he or she was found to have bipolar disorder or schizophrenia (as determined by a diagnostic interview) or an IQ score below 80 (as measured by the WASI-II), the child was considered no longer eligible for further participation and their data was not included in any final analyses. To be considered in the ADHD portion of the sample, children had to meet the DSM-IV (American Psychiatric Association, 2013) diagnostic criteria for ADHD. ADHD status was determined by clinical judgment based on results from a parent diagnostic interview combined with parent and teacher rating scale measures. All children in the non-ADHD portion of the sample failed to meet the DSM-IV's (American Psychiatric Association, 2013) diagnostic criteria for ADHD. All child participants and their participating parent/guardian were capable of speaking fluent English.

Participants were recruited through the distribution of flyers throughout the community. Flyers were distributed at local schools and children's summer camps and posted at local

businesses, particularly pediatric offices. A phone number was listed on the flyers so that interested families could contact the research assistants about participation. Payment was offered as an incentive to participate. The family received a total of $100 when all sessions were completed.

Measures

Many parent, teacher, child, and peer measures were administered during the Social Behavior Study. For this paper's research questions, only some of the parent and child measures were needed. Only the measures this study examined will be discussed.

Demographic Information Form. Parents completed a questionnaire that asked about their highest level of education, the family income, the child's race and ethnicity, and the child's gender.

Disruptive Behavior Disorder Scale (DBD; Pelham et al., 1992). The DBD had 18 items based on the DSM-IV (American Psychiatric Association, 2013) criteria for symptoms of ADHD. Parents rated the level of symptomology their child displays for each item using a 4-point Likert scale (0="not at all," 1="just a little", 2="pretty much", and 3="very much"). Consistent with the developers' instructions, scores of 0 or 1 were recoded to indicate the symptom was absent and scores of 2 or 3 were recoded to indicate presence of the symptom. Total ADHD symptom count was used for the current study because the inattention and hyperactivity/impulsivity subscales were highly correlated (r=.74). The DBD scale has test-retest reliability over a four week period, convergent validity with other ADHD rating scales, and discriminant validity between ADHD and non-ADHD diagnoses (DuPaul et al., 1998). Internal consistency for total ADHD symptom count in the current sample was .95. The mean number of total ADHD symptoms was 6.65 (SD=5.87).

Social Skills Improvement System (SSIS; Gresham & Elliot, 2008). The SSIS measures social functioning. There are 46 items on the Social Skills subscale which assess seven subdomains: Communication, Cooperation, Assertiveness, Responsibility-Taking, Empathy, Engagement in Activities, and Self-Control. Parents rate their child's behavior over the last two months using a 4-point frequency scale (0="never," 1="seldom," 2="often," 3="almost always") for each item. In the current study, the total Social Skills score across all domains was utilized (*M*=89.25, *SD*=20.43). The SSIS for parents has test-retest reliability for the total Social Skills scale of .84 (Gresham & Elliot, 2008). Internal consistency for the total Social Skills scale in the current sample was .95.

Test of Problem Solving 3 – Elementary Version (TOPS 3; Bowers et al., 1991; Zachman et al., 1994; Bowers et al., 2005). The TOPS is a test of problem solving designed to assess language-based thinking skills of students ages 6 years 0 months through 12 years 11 months. The child is shown 18 pictures and asked questions about each picture by a trained examiner. The measure takes around 35 minutes to administer, but can vary greatly depending on the child's length of answers. The questions assess six different types of critical thinking skills labeled as Making Inferences, Sequencing, Negative Questions, Problem Solving, Predicting, and Determining Causes. Examiners give the child's response a score of 0, 1, or 2 based on the intent, relevancy, and quality of the response. The sum of the items on each of the six subscales was used in the current study. See Table 1 for means and standard deviations for the TOPS subscales. Publishers of the TOPS (Bowers et al., 1991) indicate a test-retest reliability of .84.

Procedures

The Social Behavior Study received IRB approval. Participants were initially scheduled for either one 4-hour or two 2-hour individual evaluation sessions. After completion of the individual sessions, ADHD status was determined by the researchers and a group session was scheduled for the participant. Before any measures were administered, consent was obtained from the parent and assent from the child. During the individual session(s), the child completed the measures with an undergraduate research assistant. The child's session was video recorded. All questions were read to the child by the research assistant, and all of their answers were recorded by the research assistant. In a separate room, the parent completed their measures with the assistance of a graduate research assistant. With the exception of two diagnostic interviews, parents read and recorded their answers on paper themselves, using the graduate assistant only to clarify any questions they had. Group sessions consisted of ten boys or ten girls, five with ADHD and five without ADHD. All group sessions were video recorded. Teachers of the participants were emailed a link through which they could complete their measures online. Each measure was later scored and entered into a database by a research assistant. No data from the group sessions or teacher measures were used for this paper's analyses.

Results

Preliminary Analyses

Missing data was handled using listwise deletion standard to SPSS (v.22). Bivariate correlations were examined between child age, child gender, total ADHD symptoms, total Social Skills, and each of the TOPS subscales (see Table 2). Correlations were all in the expected direction. Total ADHD symptoms were negatively correlated with SSIS score and TOPS score

(*rs* = -.49 and -.20, *ps* < .01). Each problem solving construct was negatively correlated with total ADHD symptoms at the .05 significance level (see Table 2). Making inferences, sequencing, problem solving, predicting, and total TOPS score were all negatively correlated with total ADHD symptoms at the .01 significance level. Of the problem solving constructs, sequencing had the strongest negative correlation with total ADHD symptoms (*r*=-.23), but all constructs had a significant negative correlation. SSIS score was positively correlated with sequencing, problem solving, and total TOPS scores (*p*<.05). Each of the TOPS subscales was positively correlated with all of the other subscales and with the total TOPS scores at the .01 significance level. Problem solving was the subscale with the strongest positive correlation to total TOPS score (*r*=.86, *p*<.01).

Analyses to Address Research Questions

PROCESS by Andrew F. Hayes (www.afhayes.com) was run in SPSS (v.22) to test each of the six problem solving constructs as mediators between total ADHD symptoms and social skills (age and sex of the child were covariates). Mediation results can be seen in Figures 1 through 6. Significant mediation was found only for the problem solving subscale (ab = -.06, 95%CIs = -.00 to -.14). This subscale includes the ability to recognize a problem, think of solutions, evaluate the options, and choose the most appropriate solution for the situation.

Discussion

Our study aimed to find if problem solving skills mediated the relation between ADHD symptoms and social skills. The results showed that there was a strong, negative correlation between ADHD symptoms and social skills, but only one of the problem solving subscales significantly mediated this association. The mediating construct was identified as “problem

solving" by the TOPS measure developers, but this study referred to the skill as "creating the best solution" for clarity.

None of the other specific constructs that were hypothesized to be mediators (making inferences, sequencing, predicting, and determining causes) significantly mediated the correlation between ADHD symptoms and social skills. However, the hypothesis was supported by the one construct that did significantly mediate the association between ADHD symptoms and social skills (creating the best solution). Considering which aspects of problem solving skills this construct captures (i.e., ability to recognize a problem, think of solutions, evaluate the options, and choose the most appropriate solution for the situation), it may actually be the best representation of problem solving of all the subscales examined (Bowers et al., 2005). More evidence that creating the best solution is the best representation of problem solving is that of all the constructs it had the strongest correlation with total TOPS score, which is all the problem skills combined. Therefore, the hypothesis that problem solving skills mediate the relation between ADHD symptoms and social skills did receive support from this study.

The creating the best solution subscale likely involves the most steps and requires the biggest mental effort in order to give an appropriate answer. For example, item 6 of the TOPS states: "The dad ran out of medicine, and the boy is too sick to go out. What can the dad do?" For this question a child must first recognize what the problem is (the boy needs medicine but cannot leave the house, and there is no medicine at the house), come up with possible solutions (i.e., having someone else bring medicine, dad leaving the boy alone to buy medicine, boy going without medicine), choose the best one (i.e., have someone else bring the boy medicine), and articulate it fully to the examiner. That is a total of four steps; many of the items for the other subscales involve only two or sometimes three steps. As such, it makes sense that this subscale

would mediate the relation between ADHD symptoms and social skills more than the others because it requires maintaining activation of the largest amount of relevant information.

The results of this study are consistent with the results of several other studies. One such study is the study conducted by Staikova et al. (2013). Staikova's study found that pragmatic abilities mediated the relation between ADHD and social skills (2013). Pragmatic abilities are involved in the creating the best solution subscale measured in this study. Another study consistent with the results found here was conducted by Özcan et al. (2013). Their study tested a program designed to reduce social impairment by teaching problem solving strategies (Özcan et al., 2013). The results of the study found that several emotional and behavioral problems associated with social impairment in children with ADHD were reduced after the children completed the program (Özcan et al., 2013). The program was designed to give the children assessment abilities to help them solve their problems (Özcan et al., 2013). Our study's findings are also consistent with the claim by Aberson, Shure, and Goldstein that problem solving can reduce impulsivity in children with ADHD which in turn can reduce their number of emotional problems that are associated with social impairment (Aberson et al., 2007). Because creating the best solution involves evaluating possible solutions and choosing from them (a step that the other subscales do not include), children who are able to perform this step may have better control over their impulsivity because they are not simply blurting out the first solution to the problem that they think of. Control over impulsivity may give them the upper hand in social skills as well. The difference the added step makes could also be the ability to sustain multiple solutions in working memory at once and/or to maintain attention through the entire (longer) mental process. In prior research, both impulsivity and sustained attention have been shown to mediate the association between different symptoms of ADHD and social impairment, and working

memory and social impairment have been correlated (Bunford et al., 2015). Regardless of the mechanism behind it, this additional step involved in the creating the best solution subscale is likely the key difference that explains why none of the other subscales mediated the association between ADHD symptoms and social skills.

Implications

The results of this study provide some support for the hypothesis that problem solving skills mediate the relationship between ADHD symptoms and social impairment. However, since only one of the constructs showed significant mediation, the results show that it may be a more specific type of problem solving that mediates the relation than originally thought. More research needs to be done to clarify which components of problem solving specifically relate to the social impairment that is common among children with elevated ADHD symptoms. If the beneficial elements of problem solving skills can be teased out, treatment based on teaching those skills may be created to improve social functioning. The "I Can Problem Solve" (ICPS) program, which teaches children to think of as many possible solutions to a problem as they can, and was created for the purpose of social skills training, has already been shown to decrease the number of emotional and behavioral problems experienced by children with ADHD (Özcan et al., 2013). This study provides a starting point for research that can eventually lead to more and better treatments to alleviate social impairment in children with ADHD.

Limitations

This study contained several limitations. First, it was not experimental in nature, so no causal conclusions can be drawn. However, mediation was shown, which means that the relation between problem solving skills, ADHD symptoms, and social skills is more complex than a causal relationship, which is valuable information for the treatment of ADHD. Second, the

results found by this study cannot be assumed to apply to children with a diagnosis of ADHD because this study evaluated ADHD symptoms continuously. Looking at ADHD symptoms continuously is beneficial, however, because both children with and without ADHD were included in the sample and all levels of symptomology were analyzed. Another limitation of this study could be that the constructs measured by the TOPS do not accurately or fully represent true problem solving skills. Maybe all problem solving skills used in real life involve the added step present in creating the best solution. As a scientific measure, the TOPS may not mimic a real world setting sufficiently. However, developers of the TOPS designed it with the intention of making it as representative of real life settings and problems as possible. A final possible limitation to mention is parent reports were used to measure both ADHD symptoms and social skills. Parents may or may not have an accurate concept of their child, especially when it comes to the child's social skills because parents are usually not present for the majority of their child's peer interactions. Due to the young age of the children in this study, however, it is unclear if they would be self-aware enough for self-report, so we chose parent measures in the hopes that they would be the least biased.

Future Directions

This study requires replication to see if the results remain consistent, or if perhaps the significant mediation by creating the best solution was an error, or if the other constructs do mediate significantly, this study just failed to capture it. It would be interesting to repeat this study using a different measure to evaluate problem solving in order to compare different constructs and elements of problem solving. This study also needs to be repeated but using child measures for ADHD symptoms and social skills instead of parent measures. Another element to examine in the future research is how problem solving acts as a mediator for people with ADHD

of different ages. This study only examined children of one age group, but, because of the way problem solving skills develop over time, there might be different results for younger children, adolescents, or adults (Thornton, 1995). Since this study evaluated ADHD symptoms continuously, the study could be repeated using official ADHD diagnosis instead. Based on the research already available, treatment programs may be designed and tested on children with ADHD. The results of those types of treatment-based studies may provide the most information and be the most helpful. The results of this study mean that the role problem solving skills play in the social function of children with ADHD may be more complicated than originally anticipated. However, these results put us one step closer to discovering ways to treat the social impairment experienced by people with ADHD.

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Table 1.

Means and Standard Deviations for each of the TOPS subscales.

TOPS Subscales	*M*	*SD*
Making Inferences	26.21	4.40
Sequencing	25.60	4.84
Negative Questions	22.38	4.06
Problem Solving	24.85	4.95
Predicting	19.20	3.29
Determining Causes	17.93	3.86

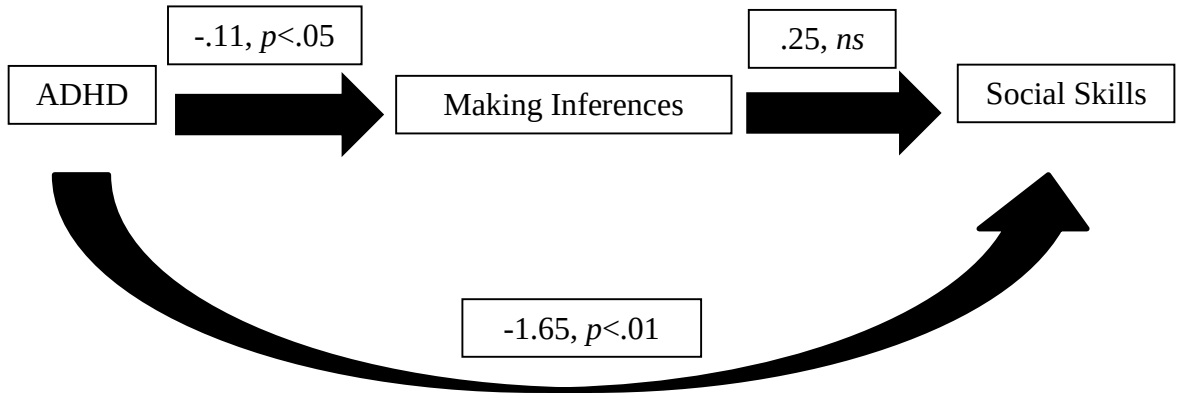
Table 2.

Correlations between total ADHD symptoms and TOPS subscales.

	Total ADHD Symptoms	SSIS Social Skills Subscale Score	Making Inferences Score	Sequencing Score	Negative Questions Score	Problem Solving Score	Predicting Score	Determining Causes Score	Total TOPS Score
Total ADHD Symptoms	1	-.49**	-.14**	-.23**	-.10*	-.18**	-.19**	-.12*	-.20**
SSIS Social Skills Subscale Score		1	.10	.14**	.04	.17*	.10	.10	.14**
Making Inferences Score			1	.58**	.62**	.61**	.47**	.58**	.80**
Sequencing Score				1	.60**	.67**	.59**	.63**	.85**
Negative Questions Score					1	.63**	.51**	.60**	.81**
Problem Solving Score						1	.54**	.66**	.86**
Predicting Score							1	.56**	.73**
Determining Causes Score								1	.82**
Total TOPS Score									1

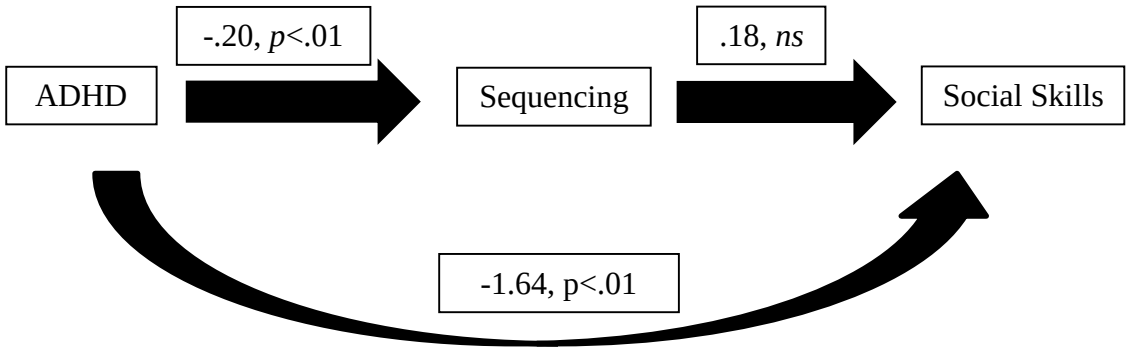
**. Correlation is significant at the 0.01 level ($p<.01$).

*. Correlation is significant at the 0.05 level ($p<.05$).



Mediation effect = -.03
95% CI = -.10 to .02

Figure 1. The results from examining Making Inferences as a mediator between ADHD symptoms and Social Skills.



Mediation Effect = .04
95% CI = -.14 to .04

Figure 2. The results from examining Sequencing as a mediator between ADHD symptoms and Social Skills.

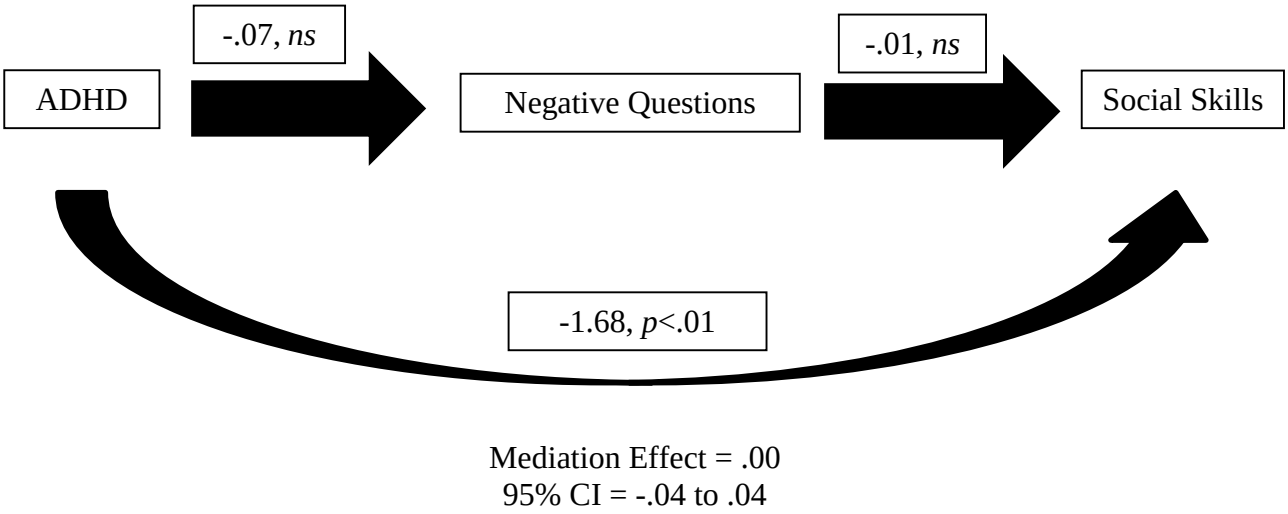


Figure 3. The results from examining Negative Questions as a mediator between ADHD symptoms and Social Skills

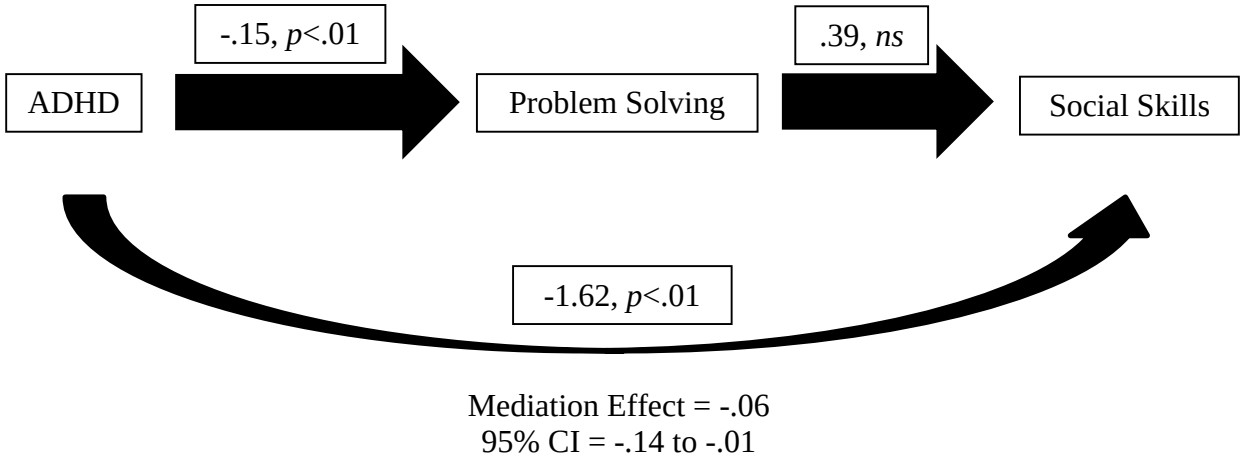


Figure 4. The results from examining Problem Solving as a mediator between ADHD symptoms and Social Skills.

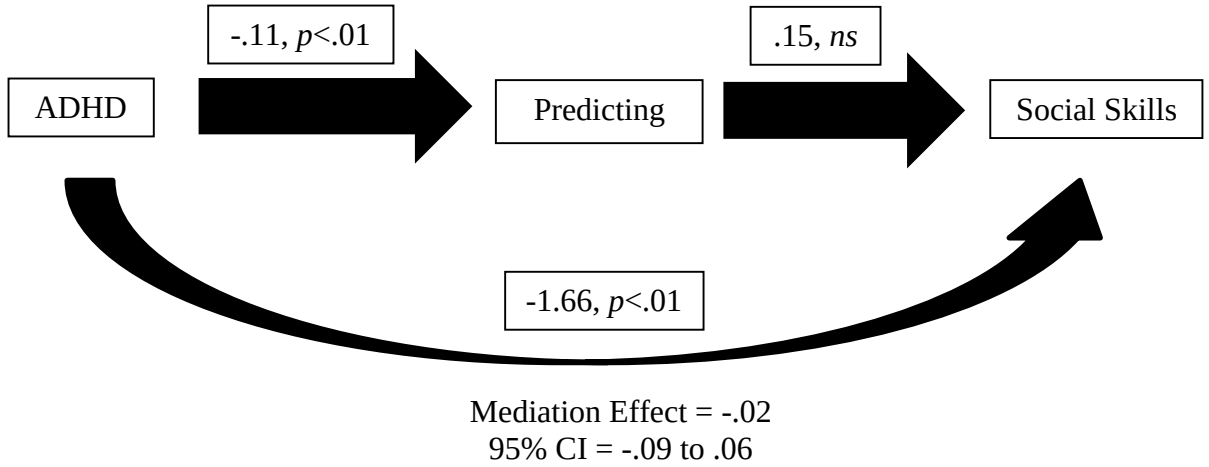


Figure 5. The results from examining Predicting as a mediator between ADHD symptoms and Social Skills.

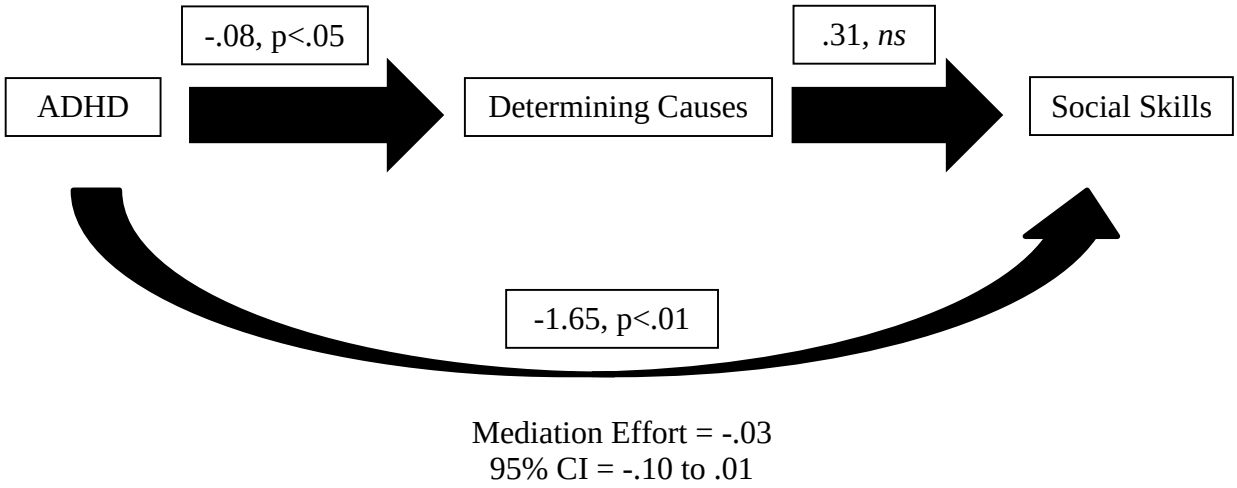


Figure 6. The results from examining Determining Causes as a mediator between ADHD symptoms and Social Skills.